NUMERICAL MODELLING OF RC BEAMS WITH BAMBOO REINFORCEMENT USING FINITE ELEMENT ANALYSIS (ANSYS)

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kajian ini bertujuan untuk mengkaji tingkah laku rasuk konkrit bertetulang dengan tetulang buluh separa dan sepenuhnya. Objektif penyelidikan adalah untuk menentukan ciri-ciri geometri elemen, untuk menentukan sifat RC pepejal dan rasuk RC dengan bar buluh yang diletakkan samaada separa dan sepenuhnya di dalam rasuk RC apabila digunakan menggantikan bar besi dari segi corak beban dan corak retak dalam analisis unsur terhingga. Keputusan analisa unsur terhingga telah disahkan dengan hasil eksperimen. Sebanyak tiga rasuk dengan dimensi 120 x 300 mm dengan panjang 1600 mm telah dimodelkan sebagai rasuk disokong mudah dalam analisis tiga dimensi menggunakan ANSYS. Jenis rasuk yang dimodelkan termasuk rasuk pepejal (tanpa tetulang, tetulang separa dan tetulang penuh) menggunakan buluh. Di sini, analisis elemen terhingga tidak linear dilakukan untuk menilai prestasi buluh sebagai tetulang dalam rasuk konkrit. Pemodelan berangka dilakukan pada pancaran kendali, pengganti buluh separa dan diganti sepenuhnya dengan buluh sebagai penguatan. Dalam kajian ini, bar penguat telah dimodelkan dengan menggunakan bar berdiameter 10 mm untuk tetulang atas dan bawah serta 6 mm diameter stirrup dengan jarak 300 mm pusat ke pusat. Dari hasil analisa unsur terhingga, beban utama untuk pancaran kawalan didapati 58.15 kN. Beban untuk BR ialah 48.46 kN yang hanya 78% daripada beban CB manakala BSR sampel memperoleh beban 17.78 kN yang mana 64% lebih rendah daripada BR dan hanya mencapai 31% berbanding CB. Beban muktamad bagi rasuk kawalan menunjukkan bahawa beban kegagalan CB, BR, dan BSR adalah 58.18kN, 48.46kN dan 17.78kN dengan pesongan 38.67 mm, 19.98 mm dan 10.89 mm. Dari hasil analisa elemen terhingga, beban mampatan untuk rasuk kawalan menunjukkan beban kegagalan CB, BR, dan BSR adalah 58.18kN, 48.46kN dan 17.78kN dengan pesongan masing-masing 38.67mm, 19.98mm dan 10.89mm. Di akhir ujian, dapat disimpulkan bahwa buluh dapat digunakan untuk menggantikan penguatan besi dalam rasuk bertulang. Aplikasi ini boleh digunakan dalam struktur struktur bangunan kecil untuk mengurangkan penggunaan keluli.

ABSTRACT

This research aims to investigate the behavior of reinforced concrete beams with partially and fully bamboo reinforcement. The objective of the research was to determine the geometrical properties of the element, to determine the behavior of solid RC beams and RC beams with partially and fully bamboo reinforcement in terms of load-deflection and crack pattern in finite element analysis. The finite element analysis results were validated with the experiment results. A total of three beams with a dimension of 120 x 300 mm with a length of 1600 mm were modeled as simply supported beams in a three dimensional analysis using ANSYS. The types of beam modelled include solid beam (without reinforcement, partial reinforcement and fully reinforcement). Here a nonlinear finite element analysis is carried out in order to evaluate the performance of bamboo as reinforcement in concrete beam. The numerical modelling was conducted on control beam, partial bamboo replacement and fully replaced with bamboo as reinforcement. In this research, the reinforcement bars were modeled as 10 mm diameter bar for top and bottom reinforcement as well as 6 mm diameter stirrups with spacing of 300 mm center to center. From the finite element analysis results, the ultimate load for control beam was found to be 58.15 kN. The load for BR was 48.46 kN which is only 78% of the load of CB whereas the sample BSR obtained the load of 17.78 kN which is about 64% lower than BR and only achieved 31% compared to CB. The ultimate load for control beams was show that the failure loads for CB, BR, and BSR are 58.18kN, 48.46kN and 17.78kN with deflections of 38.67 mm, 19.98 mm and 10.89 mm respectively. In the end of the testing, it can be concluded that bamboo can be used to replace steel reinforcement in reinforced concrete beam. This application can be used in small structures of buildings structures in order to reduce the consumption of steel.

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LIST OF SYMBOLS

m	meter
mm	millimetre
kN	Kilo Newton
MPa	Mega Pascal
GPa	Giga Pascal
E	Modulus of Elasticity
v	Poisson’s ratio

LIST OF ABBREVIATIONS

3D	3 Dimensional
RC	Reinforced Concrete
CB	Concrete Beam
BSR	Bamboo Steel Reinforced
BR	Bamboo Reinforced
FEA	Finite Element Analysis

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Construction industry is considered as an industry which exploits the environment the most. Concrete is the most important building material due to its high compressive strength characteristic. It is incorporated with steel as reinforcement to cater on its weakness in tensile strength. The combination of both materials which formed reinforced concrete is able to sustain dead load as well as live load of building structures. Due to this large production of concrete and steel is needed to cater the demand. Indirectly, this has contributed to environmental deterioration. Besides that, steel is susceptible to corrosion in the presence of oxygen and water. The rate of steel corrosion is dependent on the concrete's electrical resistivity, moisture content and the rate at which oxygen migrates through the concrete and causing steel to corrode. Carbonation and chloride attack will accelerate corrosion due to the reduction of alkalinity in concrete. Therefore, there is a need to begin the search for materials that are eco-efficient which will be the substitute for steel as reinforcement in concrete.

Nowadays, many researchers have been done using available natural resources. Bamboo is an example of natural resources that has the potential to be substitute of steel reinforcement in reinforced concrete. Generally, bamboo is known as a giant grass which grows rapidly in tropical and subtropical regions. Its strength which is greater than timber and its tensile strength is approximately half as compared to steel making it suitable to be substitute to steel reinforcing bar in concrete (Khare, 2005). Furthermore, bamboo is light weight compared to steel. The utilization of bamboo as reinforcement will consequently reduce the cost of construction. This would be beneficial in which high strength of

building can be achieved with lower cost. In short, bamboo has the potential to replace steel as reinforcement in reinforced concrete due to its characteristic to be cheap, easily available and most importantly strong in tension and compression.

1.2 PROBLEM STATEMENT

The popularity of concrete as building material in construction industry is well known and it is produced more than 10 billion tons per year (Meyer, 2009). This is due to its relatively high compressive strength properties. Steel is made up from iron which is found abundant in earth crust. However, it will undergo depletion if continuous exploitation is carried out. In short, steel is not a renewable resource. Furthermore, rapid development and production of materials especially steel, iron and cement have given enormous impact to the environment. Steel industry has contributed to pollution which endangered to the humankind. Due to this, many researchers begun to search for materials that are renewable as well as have eco-efficient characteristic to be substitute for steel. Nowadays, many researchers have been done using one of the available natural resources which is the bamboo to be a potential material used as substitute for steel reinforcement. This is due to its characteristic to be cheap, easily available and most importantly strong in tension and compression. Malaysia has abundant bamboo resources which is not widely been utilized. In this study, finite element analysis is used to analyse its effects and load- deflection curve and crack pattern are generated. The reason of using finite element analysis is to validate results with the laboratory testing. Lab tests have some disadvantages such as time consuming, costly materials and tedious procedure to obtain the data. Finite element analysis can be used to predict the outcomes using various conditions without going through the laboratory testing, which save a lot of time and labour cost.

1.3 OBJECTIVES OF STUDY

This study was conducted to achieve the following objectives:

i. To identify the geometrical properties of element that used in this study
ii. To determine the numerical behaviour of solid RC beam, partial, and fully reinforced bamboo in 3D finite element analysis
iii. To validate the result of finite element analysis with previous experimental work using three dimensional (3D) finite element analysis, ANSYS

1.4 SCOPE OF STUDY

In this study, three-dimensional modelling using software, ANSYS been conducted to run the numerical analysis of finite element method to solve the approximate solution in term of stress, strain, and load-deflection and crack pattern. From previous experimental work, for physical properties of bamboo sticks, five tests were conducted such as density, initial moisture content, water absorption, compression and tensile tests. Based on the results obtained, proper adaptations were applied on bamboo reinforcement in reinforced concrete beams. 3D modeling was conducted to investigate the behavior of beam in terms of load-deflection behavior, crack pattern and failure mode. There were a total of three types of beams to be analyzed to verify the results. The first one was the RC beam, which acted as control beam while the other two beams were partially and fully reinforced with bamboo. All the beams were modeled accordingly and tested by applying four-points loading method. The load-deflection curve and crack pattern were identified as well. The stress-strain diagram was then obtained and the results from modeled analysis then compared with laboratory experimental results for validation. The dimension of the RC beams used for this study was 120 mm x 300 mm with length of 1600 mm. The steel reinforcement used for the RC beams were two steel bars with 10 mm diameter for both tension and compression region. Shear link used was 6 mm diameter at 300 mm centre to centre.

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